1 ENVIRONMENTAL SETTING

The Mackenzie Gas Project (the project) is located within the Northwest Territories (NWT) of Canada, extending from the Mackenzie Delta in the north to just inside the Northwest Territories–Alberta boundary in the south (see Figure 1-1).

The project study area encompasses the Mackenzie Delta region and the Mackenzie Valley, including a wide variety of ecological conditions.

Figure 1.1 has been removed for the purposes of reducing file size and can be viewed as a graphic separately. This document can be accessed through the link in the Table of Contents reference web page.

1.1 Air Quality

The air quality within the project study area is typical of northern environments in Canada. The concentrations and deposition rates of airborne compounds are much lower than in southern Canada, where measurable baseline air concentrations are caused primarily by emission sources in the area.

The natural background air quality includes gaseous and particulate emissions from:

- terrestrial and marine sources
- remote volcanic activity
- forest fires

Anthropogenic emission sources include:

- ground, marine, e.g., barge traffic, and aircraft transportation
- oil and gas exploration and development
- home heating by fuel oil, natural gas or wood combustion
- crude oil production facilities near Norman Wells
- oil and gas facilities in northwestern Alberta
- electric power generation

A literature review, combined with the results of the 2001 to 2003 air quality monitoring data within the study region, shows that concentrations of the following gases or compounds are either below detection limits or are effectively zero:

- sulphur dioxide (SO_2)
- oxides of nitrogen (NO_X)
- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- volatile organic compounds (VOCs)
- particulate matter ($PM_{2.5}$)
- potential acid input (PAI)

Ozone (O_3) can periodically exceed federal objectives. However, this is likely caused by intrusion of stratospheric ozone that is closer to the ground at higher latitudes.

The current climate conditions in the project study area, defined by the average conditions over the last five years of available data, i.e., 1996 through 2000, are shown in Table 1-1.

Table 1-1: Summary of Current Climate Conditions by Region

Administrative Region	Current Climate Condition[1]			
	Average Temperature (°C)	Minimum Temperature (°C)	Maximum Temperature (°C)	Total Precipitation (mm)
Inuvialuit Settlement Region	-10.27	-32.63	14.34	190.98
Gwich'in Settlement Area	-7.63	-32.24	19.77	347.45
Sahtu Settlement Area	-5.61	-33.67	22.92	210.25
Deh Cho Region	-2.07	-30.06	23.46	390.81
Northwestern Alberta	-0.61	-29.67	23.41	317.62

NOTE:
1 Current conditions are determined as the average of the data from 1996 to 2000

These current conditions are different from conditions in the past. Table 1-2 summarizes, by region, the calculated climate trends for the 30-year period between 1971 and 2000.

Table 1-2: Summary of Historical Climate Trends

Administrative Region	Change in Climate Condition[1]			
	Average Temperature (°C)	Minimum Temperature (°C)	Maximum Temperature (°C)	Total Precipitation (mm)
Inuvialuit Settlement Region	+1.5	+2.5	+0.9	+5.2
Gwich'in Settlement Area	+2.0	+5.1	+0.1	+1.5
Sahtu Settlement Area	+1.3	+2.4	+0.3	-49.0
Deh Cho Region	+1.7	+4.2	+1.0	+5.1
Northwestern Alberta	+1.1	+2.3	+0.3	+9.2

NOTE:
1 The 30-year change in climate conditions was determined using the available 50-year climate dataset

1.2 Noise

The project study area is quiet relative to more developed parts of Canada. Sounds are largely natural, including those made by wind, animals and rainfall.

The limited anthropogenic sources of noise are localized and intermittent, and include:

- vehicle traffic
- barge and boat traffic
- air traffic, i.e., helicopter and fixed-wing aircraft
- oil and gas exploration activities
- crude oil production facilities in Norman Wells

At Niglintgak and the Inuvik area facility, there is currently no industrial presence within audible distance of the sound monitoring sites. At the Inuvik area facility site, air traffic at the Inuvik Airport can occasionally be heard.

At Norman Wells, a low-frequency rumble can be heard most of the night from 22:00 to 05:00, which probably originates at the Imperial Oil facilities.

1.3 Aquatic Resources

1.3.1 Groundwater

Groundwater can form the baseflow for streams and maintain under-ice flow, providing winter habitat for fish. Areas of groundwater recharge or discharge are indicated by surface features, such as areas of open or flowing water or icings, i.e., accumulation of ice formed by continuous freezing of slowly discharging water.

1.3.1.1 Production Area

Groundwater in the production area moves mostly through shallow flow systems in the active layer on top of the permafrost. Unfrozen groundwater exists as taliks, and occurs beneath deep lakes and large rivers.

Hydrogeological, i.e., groundwater, features in the production area include:

- seasonal springs and natural icings
- retrogressive thaw-flow slides along the edges of lakes and streams
- pingos
- thermokarst topography

1.3.1.2 Pipeline Corridor

Groundwater flows all year in the pipeline corridor, particularly in the karst topography in the southern regions.

Groundwater inflow to streams, in the form of springs and seeps, maintains stream baseflow. Perennial springs occur in carbonate rocks and help maintain stream flow in winter. Icings and open-water stretches along streams in winter indicate groundwater inflow.

Seasonal springs and seepages, originating from shallow flow systems in permeable sediments, also occur in zones of continuous permafrost. Many originate in ice-free sands and gravels or glacial outwash.

1.3.2 Hydrology

The Mackenzie River is the largest north-flowing river in North America. It flows from the Finlay River headwaters in British Columbia for about 4,000 km to the Beaufort Sea. The drainage basin is the second largest in North America and sixth largest in the world, draining 20% of Canada's total area.

The Mackenzie Delta is the largest Canadian delta. Surface waters of the delta include major channels, i.e., West Channel, Middle Channel and East Channel,

and minor tributary channels of the Mackenzie River and deltaic lakes. Most of the Mackenzie River flows through the Middle Channel and Kumak Channel.

1.3.2.1 Production Area

Waterbodies in the production area range from ephemeral drainages to large channels, lakes and coastal bays of the southeastern Beaufort Sea.

Waterbodies near Niglintgak and Taglu include:

- Big Lake
- Kimialuk Lake
- Yaya River
- several Mackenzie River channels:
  - Middle Channel
  - Kumak Channel
  - Kuluarpak Channel
  - Harry Channel
  - East Channel

Waterbodies in the Parsons Lake lease area include:

- Parsons Lake
- East and West Hans lakes
- Zed and Hans creeks

Lakes near Niglintgak and Taglu are low-closure lakes, i.e., lakes that are annually flooded by the Mackenzie River in the spring, and are also occasionally subject to marine influences. Other lakes in the study area, i.e., near Parsons Lake or along the Taglu and Storm Hills laterals, are not likely to be flooded by the Mackenzie River because they are at elevations sufficiently above the river.

1.3.2.2 Pipeline Corridor

The two largest tributaries to the Mackenzie River north of the Northwest Territories–Alberta boundary, the Liard and Great Bear rivers, flow within the pipeline corridor study area. Other large rivers include the Travaillant, Thunder, Tieda, Loon, Hare Indian, Blackwater and Willowlake.

Rivers in the pipeline corridor area exhibit an annual flow pattern determined by snowmelt and freezing. The maximum monthly discharge occurs between May and June. As the snow pack melts, flow gradually depends on baseflow. Mean monthly discharge decreases throughout summer and fall and into winter, as ground temperatures decline and freezeup begins. From January to March, discharge is low, because precipitation occurs as snow, and baseflow is limited by the deeply frozen land surface.

The pipeline route crosses more than 500 watercourses from the production area in the Mackenzie Delta to the Northwest Territories–Alberta boundary. These watercourses vary from ephemeral drainages to large rivers.

1.3.3 Water Quality

1.3.3.1 Production Area

Within the production area, baseline water quality data is available for three lakes and two delta channels near Niglintgak and Taglu, and from six lakes and one river in the Parsons Lake significant discovery licence area. Water samples were also collected from four lakes, the East Channel of the Mackenzie River and three rivers along the Taglu lateral and Storm Hills lateral. Field water quality parameters were measured for an additional 45 waterbodies in the production area.

The freshwater delta floodplain lakes near Niglintgak and Taglu are recharged through spring flooding by the Mackenzie River's sediment-laden waters. The duration of spring flooding, and the amount of connection between floodplain lakes and the delta channels, determines the physical, chemical and biological properties of these delta lakes.

The low-closure lakes have turbid waters and mainly inorganic sediments. Their water quality is similar to that of the Mackenzie River during the open-water season and is similar from year to year. Alkalinity levels of delta lakes indicate that these waters are usually well buffered against acid deposition. During winter, the total dissolved solids (TDS) concentration of deeper waters under ice is greater than 200% of the summer concentration, probably because of freeze-out. The channels and lakes of the delta are well supplied with nutrients. However, the productivity of these waterbodies appears to be limited by water clarity, substrate stability, abrasion and climate.

In high-closure lakes where flooding is shorter in duration and does not occur every year, local hydrologic and biogeochemical processes strongly influence water quality. Most lakes in the eastern delta flood every few years in spring. Farther south along the delta, fewer lakes flood annually.

High-closure lakes have clear waters, organic sediments and oxygen levels that are often depleted under winter ice. In these lakes, calcium carbonate precipitates during periods of rapid photosynthesis and reoxidation of reduced sulphur compounds. This can shift the ionic composition from calcium- and carbonate-dominated to calcium- and sulphate-dominated. Aquatic plant growth is often 20 times greater than in no-closure lakes.

Concentrations of total metals are mostly below guideline levels for aquatic life and drinking water. Concentrations of total aluminum and iron exceed aquatic life

and drinking water guideline values in delta channels. Other metals that occur in delta channels and some lakes at levels exceeding aquatic life guideline values include chromium, copper, lead and zinc. Total manganese levels exceed drinking water guideline levels in delta channels and some lakes. Selenium and cadmium concentrations occasionally exceed aquatic life guideline levels in some lakes.

Total organic carbon concentrations of sediments are usually low in streams and delta channels and moderate in lakes. Lakes have high levels of total recoverable hydrocarbons, whereas streams and delta channels have low to moderate levels.

Arsenic levels are commonly present at levels exceeding the interim sediment quality guideline. Arsenic concentrations are also occasionally higher than the probable effect level in lakes. Other metals present at levels exceeding guideline levels in some lakes and delta channels include cadmium, chromium, copper and zinc.

Naphthalene, C_1-substituted naphthalene and phenanthrene are often at levels exceeding the interim sediment quality guideline values in lakes and delta channels. C_1-substituted naphthalene levels also occasionally exceed the probable effect level in lakes and delta channels.

1.3.3.2 Pipeline Corridor

Most of the pipeline corridor falls within the lower Mackenzie River sub-basin, except for the part that lies within the Great Bear River sub-basin.

The proposed pipeline corridor crosses about 500 watercourses. However, about 75% of these are ephemeral or vegetated waterways or are frozen to the bottom or dry below ice during winter. In addition to the watercourses crossed by the pipeline corridor, eight lakes or ponds are located near a watercourse to be crossed by the proposed pipeline.

In early June, following the spring freshet, pH values are below 7.0, and sometimes below the minimum aquatic life guideline value of 6.5. The remaining summer and fall pH values are usually more than 6.5. Although winter data is sparse, winter pH values are often more than 6.5.

Most waterbodies are well oxygenated during all seasons.

Colour, turbidity and total suspended solids (TSS) levels are directly related to the discharge regime of rivers in the proposed pipeline corridor. Therefore, levels are usually lowest in winter and are highly variable in spring. Turbidity and TSS levels are mostly low in summer and fall. In all regions, water is usually moderately to highly coloured, with values exceeding the drinking water guideline values.

Watercourses along the proposed pipeline corridor usually have TDS and conductance levels that are highest during winter and then decline over the open-water period. Median TDS and conductance levels are mostly moderately low except for many sites in the Sahtu Settlement Area, where levels are more variable. Alkalinity values indicate that all waterbodies are well buffered.

Watercourses in the lower Mackenzie River sub-basin have variable nutrient levels because of local physical and geological variation. Total phosphorus levels in rivers and lakes indicate oligotrophic, i.e., nutrient-poor, to eutrophic, i.e., nutrient-rich conditions. However, most phosphorus is in particulate form and is not available for biological uptake.

Most metals occur at levels below aquatic life and drinking water guideline values, except for aluminum and iron. Other metals occasionally present at levels exceeding aquatic life guideline levels in the Sahtu Settlement Area and Deh Cho Region include total cadmium, chromium, copper, lead, selenium and zinc. Total manganese concentrations are occasionally higher than drinking water guideline values in the southern part of the pipeline corridor. Naturally high levels of metals are often associated with suspended solid metal concentrations.

The relative proportion of sand, silt and clay varies among waterbodies in the pipeline corridor. Total organic carbon levels of sediment are mostly low in all streams and rivers, with moderate and high levels in two lakes sampled in 2003. Total recoverable hydrocarbon levels are variable among sites, with values ranging from low to high.

Concentrations of metals and polycyclic aromatic hydrocarbons (PAHs) are typically associated with silt and clay particles. Therefore, levels vary among sites depending on particle size distribution. Metals and PAHs are usually present at levels below sediment quality guideline levels, although there are some exceptions. Exceptions include total arsenic and C_1-substituted naphthalene levels, which are often higher than the interim sediment quality guideline values.

1.3.4 Fish and Fish Habitat

The surface water features of the various physiographic regions and drainage basins within the study area directly influence fish communities and fish habitat. These features include lakes, ponds, streams and rivers that extend over the physiographic regions along the Mackenzie Valley from the production area in the Mackenzie Delta, south along the pipeline corridor to the Alberta Plateau. The predominant features in the project area are the Mackenzie River and Mackenzie Delta.

1.3.4.1 Production Area

The Mackenzie Delta includes a network of channels and is dominated by shallow floodplain lakes, some of which are recharged through spring flooding of the Mackenzie River.

The discharge of large quantities of fresh, nutrient-rich water from the Mackenzie River creates a band of reduced salinity extending through the estuary and along the shore of the Beaufort Sea. This zone provides a unique habitat that is used by marine, freshwater and diadromous fish, i.e., fish that migrate between saltwater and fresh water. During summer, diadromous fish use the zone for rearing and feeding. During the winter, the range of temperatures and salinities created by the freshwater inflow provide overwintering habitat that can be used by both diadromous and marine fish, and the occasional freshwater species. Most diadromous species in the Mackenzie system spend a part of their early and adult life in the outer areas of the Mackenzie Delta and near-shore waters of the Mackenzie estuary.

A variety of fish species occurs in the production area, including freshwater, marine, brackish and diadromous species. Some waterbodies are not inhabited by any fish, some are inhabited to only a limited extent, and some are inhabited all year by most species. Some habitats are only used by certain life stages, and others are used by all life stages.

The marine and brackish water species present in Kugmallit Bay and nearshore areas of the Beaufort Sea include:

- saffron cod
- starry flounder
- Arctic flounder
- Pacific herring
- fourhorn sculpin

Although Arctic flounder and fourhorn sculpin are the most abundant and widely distributed species in the nearshore areas, they are not abundant in Kugmallit Bay. Starry flounder, Pacific herring and saffron cod are also not abundant. The distribution of marine species relates to the salt content of the water and the salinity preferences of the species. Saffron cod, for example, occur in areas with higher salinities and are not encountered in the fresher, more turbid, areas influenced by the Mackenzie River. Similarly, fourhorn sculpin appear to avoid any areas influenced by the Mackenzie River discharge and are absent from nearshore areas of Kittigazuit Bay. Fish occurring in low numbers in Kugmallit Bay near Tuktoyaktuk Harbour include:

- Arctic cod
- polar cod

1.3.4.2 Pipeline Corridor

The mainstem of the Mackenzie River, its tributaries, delta channels and lakes provide:

- lentic habitats, i.e., standing water, as in a lake or pond
- lotic habitats, i.e., flowing watercourses, as in a river or stream

Mackenzie River tributaries along the pipeline corridor vary in size, and range from small ephemeral drainages to large rivers. The pipeline will cross about 500 streams and rivers. These include major watercourses, such as the:

- Hare Indian River
- Donnelly River
- Great Bear River
- Blackwater River
- River Between Two Mountains
- Willowlake River
- Mackenzie River
- Trout River
- Petitot River

More than 80% of the smaller streams along the corridor are ephemeral and flow only during snow melt or rain. These ephemeral drainages have poorly defined flow paths and are unlikely to provide suitable fish habitat. The remaining streams usually have discernable beds and banks. These include:

- small watercourses with intermittent flow that freeze to the bed in winter
- watercourses with flowing water under the ice or that partly freeze to the bed
- larger rivers and delta channels with flow all year

Groundwater can form the baseflow for streams and maintain under-ice flow, providing winter habitat for fish.

Smaller watercourses exhibit a variety of channel features, e.g., riffles, runs and pools, which can provide seasonal rearing and feeding habitat, and potential habitat for spring spawning. Larger streams can provide year-round habitat for fish species, including spring and fall spawning habitat and overwintering habitat in deep pools or runs. The delta channels exhibit fairly uniform habitat characteristics and can provide habitat for rearing young and adult feeding and holding, with water depths and flow suitable for overwintering.

Lakes vary in size from large and deep waterbodies, e.g., Campbell Lake, to small muskeg lakes and wetlands in the Alberta Plateau.

The Mackenzie River system, including the delta channels and lakes, supports 41 species of fish of 14 families. Of these, 20 species are harvested for food, commercially or for local consumption, or used for recreation. Use of the waterbodies by fish ranges from no use or extremely limited, to year-round by most species and all life stages.

The number of species present in the Mackenzie River is low compared to other river systems of similar size, but high for rivers in northern latitudes. This diversity is likely because of the south to north flow of the Mackenzie River that brings warmer water northwards and accelerates breakup along its length and in the Mackenzie Delta. Most species are distributed throughout the Mackenzie River and its tributaries. Arctic grayling and northern pike are the most widely distributed, also longnose sucker, slimy sculpin and lake chub. Diadromous species are more abundant in the northern parts of the Mackenzie River, the Mackenzie Delta and Kugmallit Bay, including:

- broad whitefish
- lake whitefish, also known as humpback or crooked-back whitefish
- Arctic cisco
- least cisco
- inconnu
- Dolly Varden

The diadromous and stream resident Arctic char previously reported in the lower Mackenzie River and Mackenzie Delta were recently determined to be Dolly Varden. The distribution of Arctic char is now believed to begin farther east, at the Anderson River. Chum salmon are also present in the Mackenzie River. Chum salmon enter the fresh water for spawning purposes and spend a short part of their life cycle in the Mackenzie drainage. Because of their restricted and sporadic status in the drainage, they are not considered a major species.

Northern pike, longnose sucker and Arctic grayling dominate the fish populations in the southern parts of the Mackenzie River. Occasionally, lake whitefish and round whitefish are also present.

1.4 Terrestrial Resources

An ecological land classification approach has been used to classify the terrestrial environment in the project study area. The approach included developing four broad ecological zones that differ from one another in climate, geomorphology, terrain, soil, permafrost and vegetation species composition and growth patterns. The four zones are:

- Tundra Ecological Zone
- Transition Forest Ecological Zone
- North Taiga Plains Ecological Zone
- South Taiga Plains Ecological Zone

These zones were developed based on studies such as the terrestrial ecozones of Canada (Ecological Stratification Workshop [ESWG] 1995), forest regions of Canada (Rowe 1972) and ecosites of northern Alberta (Beckingham and Archibald 1996). The project's classification system matches that of the Ecological Stratification Workshop as follows:

- the Tundra Ecological Zone matches the ESWG's Southern Arctic Ecozone

- the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones match the ESWG's Taiga Plains Ecozone

The production area lies within the Tundra Ecological Zone and the pipeline corridor lies within the Transition Forest, North Taiga Plains and South Taiga Plains ecological zones.

In ESWG's system, each ecozone is further subdivided into ecoregions including the:

- Great Bear Lake Plain ecoregion
- Norman Range ecoregion
- Mackenzie River Plain ecoregion
- Franklin Mountains ecoregion
- Horn Plateau ecoregion
- Hay River lowlands ecoregion
- northern Alberta Uplands ecoregion

1.4.1 Soils, Landforms and Permafrost

1.4.1.1 Production Area

Bedrock and Surficial Geology

The surficial geology adjacent to Niglintgak and Taglu is predominantly of modern deltaic origin. The Parsons Lake lease lies within the Pleistocene Coastal Plain.

Delta area bedrock is sedimentary, composed primarily of Tertiary shale and sandstone. Preglacial, glacial and postglacial deposits overlie the bedrock. The depth to the bedrock ranges from 70 m near Inuvik, to over 150 m near the seaward limit of the modern delta. The depth to the bedrock at Richards Island is about 60 m.

In the northern part of the Caribou Hills, near Parsons Lake, Tertiary shale is at or near the surface, beneath a thin veneer of glacial deposits. The bedrock includes poorly indurated, interbedded conglomerate, sandstone and mudstone. The bedrock in the southern part of the Caribou Hills is also exposed and comprises Cretaceous shale.

The surficial geology in the production area includes:

- recent, level alluvial deposits from the Mackenzie Delta, north and northwest of Inuvik
- hummocky glacial till, north and northeast of Inuvik

Depths of surficial deposits range from thin colluvium deposits covering bedrock in the southeast of the production area, to 150 m of silt and fine sand with high organic content near the northern limit of the delta.

The topography of the production area is mostly level to rolling, with elevations ranging from sea level in the delta, to 150 m near Parsons Lake.

Permafrost

Permafrost underlies about 65% of the Mackenzie Delta. Its distribution results from past and present climates, hydrogeological characteristics in the ground, and surface organic cover. Both Niglintgak and Taglu are within the intermediate discontinuous permafrost zone. Parts of the production area south of the East Channel of the Mackenzie River, including the Parsons Lake lease, are within the continuous permafrost zone. Permafrost thickness ranges up to 600 m in the continuous areas, but is less than 100 m in the discontinuous areas of the active delta.

Where permafrost occurs, the depth of the active layer in the soil column ranges from 30 to 100 cm.

Soils

The soil orders in the production include:

- Cryosols – ice-rich soils associated with wetlands, tundra or taiga forest conditions
- Regosols – soils that have not been weathered and are associated with active landforms such as floodplains, colluvial slopes, beaches, thaw slumps and debris flows

1.4.1.2 Pipeline Corridor

Bedrock and Surficial Geology

Surficial deposits in the Transition Forest and North Taiga Plains ecological zones include hummocky moraine and glaciolacustrine silt and clay. Bogs, fens and thermokarst depressions filled with organic-rich silts and clays occur along the northern parts of the pipeline corridor. South of Fort Good Hope, organic deposits underlie most of the pipeline corridor.

The terrain is flat and featureless, except for a few areas of hummocky topography with drumlins. The highest point is north of Fort Good Hope, and the lowest is in the narrow lowland near the Mackenzie River.

The South Taiga Plains Ecological Zone is underlain by Cretaceous bentonitic clay shale and sandstone, with occasional sinkholes and limestone outcrops near the Norman and McConnell ranges.

The surficial geology of the South Taiga Plains Ecological Zone is complex, including:

- glacial till
- glaciolacustrine sediments
- moraine
- colluvium
- bedrock exposures
- organic deposits
- alluvium

Permafrost

Permafrost in the pipeline corridor study area ranges from about 100 m deep near Inuvik, to 10 m or less in the southern margins of northwestern Alberta. The annual active layer ranges from 0.5 to 1.5 m deep. Localized patches, i.e., less than 10% of the area, of isolated permafrost occur in the Fort Simpson area. South of 60°N, to the southern limit of the pipeline, less than 10% of the land area is underlain by permafrost. Frost action and permafrost processes have created most landforms that are particular to the North, such as:

- sorted stone stripes
- polygons
- peat palsas
- frost boils
- pingos
- solifluction lobes

Soils

About 80% of the soils between Inuvik and Norman Wells have developed on mineral parent materials, including:

- 50% moraine deposits
- 15% bedrock and colluvium
- 15% glaciolacustrine deposits

Organic soils have developed over glaciolacustrine deposits and in small areas of alluvial and glaciofluvial materials along the valley. Permafrost is prevalent within 1 m of the surface.

The soils between Norman Wells and Willowlake River are deeper and less influenced by permafrost, particularly in the southern half of this area. However, as much as 40% of the soil shows evidence of some permafrost activity. Within this region, 90% of the soils are developed on mineral parent materials, of which 45% is on morainal plains and 30% is on bedrock and colluvium. Organic soils occur in about 10% of this area, and Brunisolic soils are common.

The remainder of the pipeline corridor, particularly south of Fort Simpson has organic soils covering about 25% of the area. These soils occur in low-lying plains between upland ridges and hills on morainal deposits and glaciolacustrine plains. The peat layer is over 1 m thick and is developed from sedge, moss and tamarack vegetation. Permafrost is common in bog and forest peatlands, but uncommon in fen landforms. Within this region, 75% of the soil has developed from mineral parent materials, 50% has developed from moraine deposits, i.e., till, and 15% has developed from glaciolacustrine deposits.

The North Taiga Plains and Transition Forest ecological zones are primarily underlain by Upper and Middle Devonian shales.

1.4.2 Vegetation

1.4.2.1 Tundra Ecological Zone

Abundant low shrubs, sedges and mosses characterize the Tundra Ecological Zone of the Tuktoyaktuk Coastal Plain. Vegetation communities in the production area grow on a thin veneer of unfrozen organic or granular substrate overlying the permafrost boundary. Vegetation types include dwarf shrub heath on both granular and organic substrates, with shrub height increasing in suitable microsites. Wetter areas support high-centred and low-centred polygons of patterned ground, whereas drier areas support ericaceous shrubs. Wetter areas in the patterned ground support sedges, cotton-grasses and sphagnum moss. Riparian communities support wet sedge communities and taller shrubs. Holmes Creek and Hans Creek support outliers of black spruce communities. Vegetation types on the Mackenzie River floodplain include shrub communities and wet sedge–cotton-grass meadows.

In total, 12 unique vegetation types are found in the Tundra Ecological Zone near the significant discovery licence areas and the gathering pipelines.

1.4.2.2 Transition Forest Ecological Zone

The northern part of the Transition Forest Ecological Zone is a mixture of tundra vegetation and scattered, stunted spruce forest. The uplands are laced with dense black spruce, tamarack and ground birch growing in the many shallow drainage channels that drain slopes. The southern part of the Transition Forest Ecological Zone is vegetated with scattered to open spruce and birch mixedwood forest. Poorly drained mid- and lower slopes support shrub communities, shrub fens, bogs and riparian white spruce or willow communities.

In total, 10 vegetation types are found in the Transition Forest Ecological Zone. Nine of these vegetation types are unique to this zone.

1.4.2.3 North Taiga Plains Ecological Zone

The North Taiga Plains Ecological Zone is a zone of stunted forest that extends south from the Travaillant River to the Great Bear River. North of Fort Good Hope are upland areas characterized by open scrubby forest of black and white spruce, and large burned areas with regenerating mixedwood forest. Between Fort Good Hope and the Franklin Mountains are large, flat, glaciolacustrine plains covered by a patchwork of open black spruce forest and level, poorly drained areas dominated by Labrador tea, sphagnum and reindeer lichen. The slopes of the Franklin Mountains support mixedwood forests of white spruce, black spruce and

Alaska birch. Another large burned area occurs south of Norman Wells down to the Great Bear River.

In total, 12 vegetation types are described in the local study area lying within the North Taiga Plains Ecological Zone.

1.4.2.4 South Taiga Plains Ecological Zone

The South Taiga Plains Ecological Zone contains the most diverse and productive vegetation types along the pipeline corridor. The zone extends south from the Great Bear River to the flanks of Bootis Hill in Alberta. In the uplands are closed forests of aspen, white spruce, Alaska birch and jack pine. In the more level, poorly drained terrain are extensive forests of open to scattered black spruce and tamarack. Near Fort Simpson, large patterned fens dominated by ground birch, willow, sweet gale and sedge characterize low-lying, poorly drained terrain. South of the Trout River are large areas of poorly drained upland peat plateaus covered by stunted black spruce and Labrador tea with an understorey of reindeer lichens. Broad areas have been burned near the Great Bear River, the Willowlake River and Trainor Lake within the last 20 years.

In total, 16 vegetation types are described in the study area lying within the South Taiga Plains Ecological Zone.

1.4.2.5 Rare Plants, Uncommon Communities and Tall Forests

Rare plants are species that are uncommon on the landscape either within a geographic region or globally. They contribute to the species diversity of an ecosystem.

Within the local study area, 371 sites were surveyed for rare plant species. The goal of the program was to achieve broad coverage of the variety of habitats within each ecological zone.

Across all regions, there were 83 confirmed occurrences of rare plant species. Thirty different rare plant species were identified in the study area:

- five rare plant species in the Tundra Ecological Zone
- two species in the Transition Forest Ecological Zone
- six species in the North Taiga Plains Ecological Zone
- 22 species in the South Taiga Plains Ecological Zone

In addition, a variety of uncommon vegetation communities occur throughout the study area, often associated with site-specific features, such as exposed granular substrates, lakeshores, marshes, springs, snowmelt patches or stands of tall, dense trees.

1.4.2.6 Traditionally Used Plants

Traditionally used cultural plants include those that are used for food, medicine, ceremonies or material purposes. Berry picking, especially blueberry, cranberry and cloudberry, is an important part of the traditional culture throughout the study area. A variety of species and multiple uses are indicated on species lists from each of the settlement regions and areas within the study area.

1.4.3 Wildlife

The rich vegetation in the study area supports over 66 species of terrestrial mammals, 235 species of birds, seven species of amphibians and two species of reptiles. Of these, 51 species of mammals, 117 species of birds, and two species of amphibians have been observed in the study area, identifying the importance of this region to wildlife.

1.4.3.1 Marine Mammals of the Beaufort Marine Area

Several marine mammals inhabit the Beaufort region, including beluga whales, bowhead whales, ringed seals and polar bears. These mammals are at the top of the marine food chain and are therefore important indicators of the health and productivity of the marine ecosystem.

The beluga whale is a highly important subsistence resource to the Inuvialuit community. The species is harvested primarily by hunters from Inuvik, Tuktoyaktuk, Aklavik and Paulatuk, and is shared among all Inuvialuit communities. Seasonal migrations lead to pods herding together in the summer near major outflow channels of the Mackenzie River. A particularly important area is Kugmallit Bay.

While the bowhead whale is currently classified as *endangered* in Canada (COSEWIC 2004) and *sensitive* in the Northwest Territories, it is being reassessed by COSEWIC. The population of the western Arctic bowhead stock, estimated at about 9,860, represents more than 90% of the world's population (Community of Tuktoyaktuk et al. 2000). Bowheads are now being managed to permit population recovery.

Although most polar bears winter on the sea ice, a few, primarily females and their young, will use coastal areas for denning. Pregnant females and females accompanied by young can be sensitive to disturbance. The *Southern Beaufort Sea Polar Bear Agreement* between the Inuvialuit and Inupiat recognizes the importance of the polar bear in the Beaufort region.

The ringed seal is one of the more abundant marine mammal species in the project area. The species is an important component of the Arctic marine ecosystem and is the primary prey of polar bears. Ringed seals are also an important subsistence resource for the Inuvialuit.

1.4.3.2 Production Area

Habitat Characteristics

The production area encompasses tundra habitats, which vary from drier uplands with relatively few scattered wetlands to extensive wet lowlands with numerous ponds and lakes. The Parsons Hills are a good example of drier upland tundra. They are situated along the southwest edge of the Parsons Lake lease. The most extensive low wetlands occur on the outer Mackenzie Delta.

Mammals

Characteristic mammal species that occur within the Tundra Ecological Zone include:

- barren-ground caribou
- muskox
- grizzly bear
- wolverine
- gray wolf
- muskrat
- snowshoe hare
- Arctic ground squirrel
- northern red-backed vole

Caribou are found in the production area during winter, particularly around Caribou Hills and in the Parsons Lake area. The riparian black spruce habitat and other woody vegetation in the rolling terrain provide visual and thermal cover and caribou forage.

Important areas for grizzly bear include the southern part of the Tuktoyaktuk Peninsula to Holmes Creek. The area south of Richard Island to Parsons Lake is also important, particularly where denning habitat can be found.

Birds

Bird species occurring in the project study area include:

- loons
- grebes
- waterfowl
- hawks
- eagles
- owls
- shorebirds
- gulls

- terns
- cranes
- woodpeckers
- songbirds

Most bird species are migratory and only occur in the study area during the spring, summer and fall. The outer Mackenzie Delta is considered an important area for nesting, moulting and staging waterfowl, especially for geese and tundra swans. These species provide an important subsistence source for local hunters. Concentrations of moulting and brood-rearing Canada and greater white-fronted geese, and large flocks of ducks and terns occur near Kendall Island and elsewhere along the coast of the outer Mackenzie Delta. Because of the importance of the outer delta for birds, the Kendall Island Bird Sanctuary was established in 1961. This 623-km^2 sanctuary provides habitat for over 100 species of migratory birds, including up to 7,500 snow geese. The outer Mackenzie Delta, including the sanctuary also provides nesting habitat for up to 60,000 pairs of shorebirds.

Raptors and owls within the Tundra Ecological Zone include:

- peregrine falcon (tundra subspecies)
- golden eagle
- short-eared owl

Characteristic passerines in the Tundra Ecological Zone include:

- American tree sparrow
- American golden plover
- least sandpiper
- semipalmated sandpiper
- long-billed dowitcher
- whimbrel
- red-necked phalarope

The Eskimo curlew might also occur, but has not been seen for many years.

1.4.3.3 Pipeline Corridor

The pipeline corridor transcends three ecological zones:

- the Transition Forest Ecological Zone
- the North Taiga Plains Ecological Zone
- the South Taiga Plains Ecological Zone

A great diversity of wildlife, including waterfowl, moose and caribou, and furbearers, forms an important basis for the harvest of country food.

Transition Forest Ecological Zone

The northern boundary of Transition Forest Ecological Zone represents the treeline. Twenty-eight species of mammals and one amphibian species occur in this zone. Moose and furbearers find resources in the forested areas, particularly in river valleys that are more sheltered from wind. Grizzly bear find denning sites and barren-ground caribou might winter in the project area.

A total of 70 bird species occur in this ecological zone. Raptors that occur in the Transition Forest Ecological Zone are similar to the Tundra Ecological Zone and include:

- peregrine falcon
- golden eagle
- short-eared owl

However, the forests in this zone provide more nesting, cover and forage sources for passerines, such as:

- blackpoll warbler
- gray-headed chickadee
- rusty blackbird
- bank swallow
- open-sided flycatcher
- American tree sparrow
- Harris' sparrow

The shorelines of lakes and rivers provide ideal habitat for lesser yellowlegs and the red-necked phalarope. The Canada goose, northern pintail, white-winged scoter and black tern are characteristic waterfowl.

North Taiga Plains Ecological Zone

The North Taiga Plains Ecological Zone is mostly a forested region containing closed-to-open forests of black and white spruce and white birch that are typical of the uplands and rocky ridges. A total of 36 mammal species and one amphibian species find suitable habitat in this zone. Winter mammal use is primarily concentrated within tree and shrub communities that offer better thermal and escape cover, as well as foraging opportunities than further north. During the summer, mammal use tends to be dispersed over a wider variety of vegetation types.

The peregrine falcon, golden eagle and short-eared owl are also found in the North Taiga Plains Ecological Zone. Passerines of this ecological zone include:

- the gray-headed chickadee, in open coniferous or aspen forests
- open-sided flycatcher
- rusty blackbird
- barn swallow
- bank swallow
- white-throated sparrow
- blackpoll warbler
- northern flicker

Characteristic waterfowl include:

- common snipe
- American bittern
- trumpeter swan
- Canada goose
- northern pintail
- lesser scaup
- harlequin duck
- surf scoter
- white-winged scoter
- black tern

South Taiga Plains Ecological Zone

The main upland cover types consist of open-to-closed forests of aspen, white spruce, white birch and jack pine. Forty-five mammal species and two amphibian species occur in this zone. Amphibians are possibly more abundant here than further north. The grizzly bear, on the other hand, is uncommon in this zone.

As in the North Taiga Plains Ecological Zone, furbearers and large mammals of the South Taiga Plains Ecological Zone concentrate, in the winter, within tree and shrub communities where thermal and escape cover is better than in the open vegetation. In the summer, wildlife are more dispersed in other vegetation types. The birds of this zone are similar to those in the North Taiga Plains Ecological Zone.

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